Question [1]: [25 mark]

(a) Convert the following numbers showing all steps. [3 marks each]

$(11010110001)_2$ = (6 B1 $)_{16}$

(7D3.A$)_{16}$ = (3723.50$)_8$

0111 1101 0011 . 1010

3 7 2 3 . 50

(9 $)_{10}$ = (1011 $)_{6-2-2-1}$

or

1101

(-30 $)_{10}$ = (11100001 $)_{1\text{'s complement}}$ use 8-bit word length

64 32 16 8 4 2 1

0 0 1 1 1 1 0 ← Sign & Mag.

(11001111 $)_{1\text{'s complement}}$ = (11010000 $)_{2\text{'s complement}}$

10110000

11010000

(b) Convert and add the following numbers in Binary Coded Decimal BCD [4 marks]

$(63)_{10}$+$(37)_{10}$=

	0110	0011
	0011	0111
	1001	1010
		0110
	1010	0000
+	0110	
0001	0000	0000

37
63
100

(c) Find the range of numbers which can be represented in 2's complement using 6-bit word length. **[3 marks]**

$\{-2^{n-1} \rightarrow 2^{n-1}-1\}$

$-2^5 \rightarrow 2^5-1$

$[-32 \rightarrow +31]$

(d) Add the following 2's complement numbers and indicate if over flow occur. [3 marks]

111111

1111011
+1000111
X 1000010

No over flow.

Question [2] : [20 marks]

(a) Simplify the following function: **[10 marks]**

$\bar{D}$ E

$$F1(A,B,C,D,E)=\{[\overline{(A\oplus C)}\bullet(C\oplus C)]+\overline{(D\bullet D)}\}\oplus\{(E\bullet E)\bullet[\overline{(C\oplus C)}+\overline{(A\oplus B)}]\}$$

0 0 1 1 1

$= \bar{D} \oplus E$

5 5

(b) Simplify the following function using consensus theorem:

$$F(W,X,Y,Z)=\cancel{(X+Y+Z)}\,(W+X+Y)\,(W'+Y+Z)\,(X'+Y'+Z')\quad \textbf{[5 marks]}$$

$= (W+X+Y)(W'+Y+Z)(X'+Y'+Z')$

a' a

$$F(a,b,c,d)=a'c'd+a'bd+\cancel{bcd}+acd\quad \textbf{[5 marks]}$$

c' c

$= a'c'd + bcd + acd$

or

$= a'c'd + a'bd + acd$

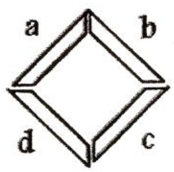
Question [3]: [30 mark]

You are required to design a circuit that takes its input from a decimal keyboard, such as the one on your mobile phone and produces output directions on a 4-segment display, such as the one shown below. The keyboard generates a Binary Coded Decimal (BCD) number. Pressing the following keys produces the shown outputs:

Pressing number 2 key would produce an Up indication, by lighting the segments a and b.

Pressing number 8 key would produce a down indication, by lighting the segments c and d.

Pressing number 4 key would produce a left indication, by lighting the segments a and d.



Pressing number 6 key would produce a right indication, by lighting the segments b and c.

Pressing number 1 key would produce a LU indication, by lighting the segment a.

Pressing number 3 key would produce a RU indication, by lighting the segment b.

Pressing number 7 key would produce a LD indication, by lighting the segment d.

Pressing number 9 key would produce a RD indication, by lighting the segment c.

Assume that only the above mentioned keys work and all other keys on the keyboard are disabled.

For the above problem do the following;

a. Construct the truth table of the system.

#	A	B	C	D	a	b	c	d	$\bar{d}$
0	0	0	0	0	X	X	X	X	X
1	0	0	0	1	1	0	0	0	1
2	0	0	1	0	1	1	0	0	1
3	0	0	1	1	0	1	0	0	1
4	0	1	0	0	1	0	0	1	0
5	0	1	0	1	X	X	X	X	X
6	0	1	1	0	0	1	1	0	1
7	0	1	1	1	0	0	0	1	0
8	1	0	0	0	0	0	1	1	0
9	1	0	0	1	0	0	1	0	1
	1	0	1	0	X	X	X	X	1
	1	0	1	1	X	X	X	X	X
	1	1	0	0	X	X	X	X	X
	1	1	0	1	X	X	X	X	X
	1	1	1	0	X	X	X	X	X
	1	1	1	1	X	X	X	X	X

2 - 4 inputs & 4 outputs
1 - Full Truth Table ie 16 entries [illegible]
2 - Key 0 & Key 5 are don't cares
2 - Combinations 10 to 15 are don't cares
1 - 1's are correct, even if don't cares are assumed as zeros, [illegible]
1 - [illegible] are correct

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b. Find the Minterm expansion of <u>segment c</u> in decimal notation.

$$c = \sum m(6,8,9) + \sum d(0,5,10,11,12,13,14)$$ 7

c. Find the Maxterm expansion of <u>segment d'</u> in decimal notation.

$$\bar{d} = \prod M(4,7,8) \cdot \prod D(0,5,10,11,12,13,14)$$ 7

$$d = \prod M(1,2,3,6,9) \cdot \prod D(0,5,10,11,12,13,14)$$

d. Find the minimum sum of products for <u>segment b.</u>

CD \ AB	00	01	11	10
00	X	0	X	0
01	0	X	X	0
11	1	0	X	X
10	1	1	X	X

$$b = C\bar{D} + \bar{B}C$$ 7

1 - K map structure
1 - 0's & 1's are entered ok.
1 - X's exist for m_0 & m_5
1 ~~2~~ - X's are in correct locations for 10 - 15 combinations.
1 - There are 2 groups of 4 cells.
1 ~~3~~ - Correct Function
1 ~~2~~ - Function according to groups.

By Boolean Algebra

2 - 3 minterms of 4 $+\bar{A}\bar{B}CD + \bar{A}\bar{B}C\bar{D} + \bar{A}BC\bar{D}$
2 - Result minimum $+\bar{A}\bar{B}C + \bar{A}C\bar{D}$

3 - Using Don't Cares to reduce further

Question [4]: [25 mark]
A logical function is given as:

$$F(a,b,c,d)=\Pi M(0,2,5,7,10) \cdot \Pi D(8,13,14)$$

a) Using K-Map find the **minimum SOP** and **minimum POS** expressions of the function.

b) Realize the **minimum SOP expression (obtained in part a) with *three-level* only 2- input NAND gates** circuit.

c) Realize the **minimum POS expression (obtained in part a) with *two-level* only NOR gates** circuit.

cd \ ab	00	01	11	10
00	0	1	1	X
01	1	0	X	1
11	1	0	1	1
10	0	1	X	0

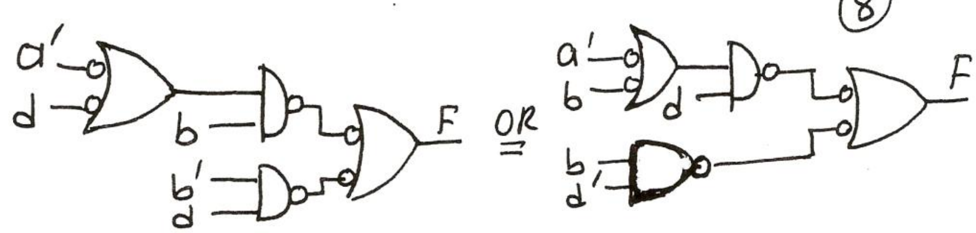
a) $F = ab + b'd + bd'$ or

$F = b'd + bd' + ad$ (8)

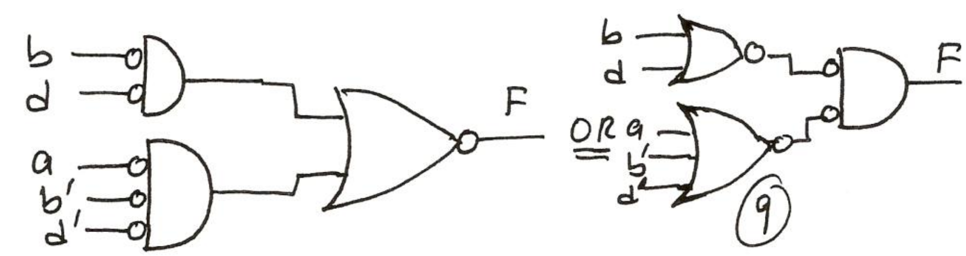
$\bar{F} = b'd' + a'bd$

$F = (\bar{F})' = (b+d)(a+b'+d')$

b) $F = b(a+d') + b'd = d(a+b') + bd'$ (8)



c)



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